Plasma lipid and lipoprotein concentrations of men consuming a low-fat, high-fiber diet[1,2]

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ABSTRACT This study assessed the influence of a low-fat, high-fiber diet on blood lipid concentrations of 42 men with desirable or moderately elevated cholesterol concentrations. A low-fat diet (19% fat, 4% saturated fatty acids, 4.6 g fiber/MJ) was compared with a high-fat diet (41% fat, 15% saturated fatty acids, 2.0 g fiber/MJ) and with subjects' self-selected diets. Substituting the low-fat for the high-fat diet decreased total, low-density-lipoprotein, and high-density-lipoprotein cholesterol by 17–20%. Lipid changes between 6 and 10 wk were minor. A reduction in plasma cholesterol of > 0.52 mmol/L was achieved with the low-fat diet in 59% of men changing from their self-selected diets and in 79% changing from the high-fat diet. Percent reduction was independent of subjects' cholesterol classification. Results indicate that significant reductions in plasma cholesterol can be achieved by the majority of men committing to a low-fat, high-fiber diet. *Am J Clin Nutr* 1992;55:689–94.

KEY WORDS Diet, dietary fat, dietary fiber, blood lipids, lipoproteins, plasma cholesterol, HDL cholesterol, LDL cholesterol

Introduction

Prominent scientific panels, including the National Cholesterol Education Program (NCEP) Panel on Population Strategies for Blood Cholesterol Reduction, have recommended that healthy Americans change their eating habits to reduce their risk of coronary heart disease (CHD) (1–3). While maintaining the importance of dietary intervention for high-risk individuals, the NCEP panel now encourages healthy Americans aged ≥ 2 y to adopt, as part of a healthy lifestyle, a diet that is low in fat, saturated fatty acids, and cholesterol (3).

Individuals with cholesterol concentrations of ≥ 6.21 mmol/L have the greatest incidence of CHD, but a larger number of cases comes from the vastly larger group of Americans with lower cholesterol concentrations. Approximately 45% of adult Americans have a desirable concentration of plasma cholesterol (3), < 5.17 mmol/L, and ≈30% have moderately elevated concentrations, 5.17–6.18 mmol/L.

In view of the new emphasis on dietary modification in these groups, we have assessed the efficacy of a low-fat, high-fiber diet in the reduction of plasma cholesterol and low-density-lipoprotein (LDL) cholesterol in subjects with desirable or borderline-high concentrations of cholesterol. Additionally, we have compared the two groups with regard to response to a low-fat, high-fiber diet.

Methods

Subjects

Subjects were healthy men recruited from the Beltsville, MD, area. Of the 46 men selected to participate, 4 were dropped in the first weeks of the study because of inability to follow the study protocol. The remaining 42 successfully completed all phases of the study. These subjects ranged in age from 19 to 56 y (34 ± 1.4 y, $\bar{x} \pm$ SE) and in weight from 56.8 to 121.8 kg (78.9 ± 2.1 kg). Criteria for subject selection included the following: *1*) normal blood and urine chemistry values; *2*) no history of diabetes, hypertension, gout, or other metabolically related diseases; *3*) not currently on medication; *4*) body weight 80–130% of Metropolitan Life Insurance table of desirable weights (8); and *5*) not currently on an atypical, including vegetarian, diet. Subjects' plasma cholesterol concentrations, retrospectively assessed as an average from self-selected dietary periods, fell within desirable or borderline-high categories except for one subject who had a slightly higher value, 6.26 mmol/L.

Informed consent was obtained from all subjects in accordance with institutional guidelines. All procedures were approved by the Institutional Review Boards of the National Cancer Institute, National Institutes of Health, and Georgetown University School of Medicine. Subjects, paired by age, smoking status, and body mass index [weight (kg)/height^2 (m^2)] (4), were randomly assigned to one of the two diet-order groups, ie, high fat to low fat or low fat to high fat.

Self-selected diets

During prestudy and poststudy periods, subjects recorded all food and beverage intake, including alcoholic beverages, for 7

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consecutive days. Dietitians instructed subjects concerning weighing food items and other aspects of keeping accurate food records and also reviewed records daily with subjects. Records for the prestudy period were analyzed in the Lipid Nutrition Laboratory, Beltsville Human Nutrition Research Center (BHNRC). Daily nutrient intake for each subject during the prestudy period was calculated from food tables based on USDA *Handbook 8* revised (5) and from food-industry sources. Poststudy records were analyzed at the University of Minnesota Nutrition Coordinating Center (Minneapolis). For estimation of the total-dietary-fiber (TDF) intake in the prestudy period and from the experimental diets, USDA *Handbook 8* data were updated by using data from the *Provisional Table on the Dietary Fiber Content of Selected Foods* (6) and from the *Handbook of Dietary Fiber* (7) with preferential usage of duplicate data being given to *Handbook 8* and the provisional table. Poststudy fiber values were included in the record analyses by the Minnesota Nutrition Coordinating Center.

Experimental diets

During the experimental feeding periods, the subjects ate each diet for 10 wk in a crossover pattern. The high-fat diet was designed to reflect the dietary characteristics of Beltsville-area volunteers, including calories from fat; relative distribution of polyunsaturated, monounsaturated, and saturated fatty acids; and cholesterol concentrations, as determined in earlier studies (8). Both diets were calculated by using the USDA *Handbook 8* database and were composed of foods commonly available to the US public. A 7-d menu cycle was used, and each menu met the recommended dietary allowances for known nutrients (9). The experimental diets are called high fat and low fat for convenience; other nutrients differed substantially between the two diets. The high-fat diet contained 41% of calories from fat, 15% of calories from saturated fatty acids, 45 mg cholesterol/MJ and 2.0 g TDF/MJ (8.4 g/1000 kcal). The low-fat diet contained 19% of calories from fat, 4.4% of calories from saturated fatty acids, 18 mg cholesterol/MJ, and 4.6 g TDF/MJ (19.3 g/1000 kcal).

When the low-fat diet was designed, emphasis was placed on obtaining a mixture of fiber from legumes, cereals, and fruits and vegetables rather than on obtaining major single-source, high-fiber foods or classes of foods. Only the soluble fraction of the fiber would be expected to lower plasma cholesterol. However, values for soluble fiber content of foods are method dependent, making accuracy of soluble-fiber data difficult to assess. Thus, no attempt has been made to estimate soluble-fiber content of the diets.

All meals for experimental feeding were prepared in the Human Study Facility, BHNRC. On weekdays, breakfast and dinner were eaten in the BHNRC facility and takeout lunches were provided. Weekend meals were prepackaged in the Human Study Facility for home consumption. Subjects were not allowed to consume alcohol or to take vitamin or mineral supplements during experimental feeding periods. Caloric intake was adjusted in 1.7-MJ (400-kcal) increments, as needed, to maintain a relatively constant body weight during the experimental feeding periods. To monitor possible changes in nutrient intake associated with the order in which the diets were fed, actual nutrient consumption of each subject was calculated for each diet-order group.

Lipid measurements

During weeks 6 and 10 of each period, blood was drawn from antecubital veins of subjects after an overnight fast, mixed with 1.5 g disodium EDTA/L, and cooled on ice. Plasma samples were analyzed at the George Washington University Lipid Research Clinic, where standardization with the Centers for Disease Control was maintained throughout the study for analysis of triglycerides, total cholesterol, and high-density-lipoprotein (HDL) cholesterol. Both 6- and 10-wk samples were analyzed for triglycerides, total cholesterol, and HDL cholesterol. Samples collected at week 10 were evaluated for these indices and also for LDL, HDL_2, and HDL_3 cholesterol.

Cholesterol, triglycerides, and triglyceride blanks were analyzed enzymatically with Abbott ABA-100 analyzers with reagents supplied by Abbott Diagnostics (Chicago). Reagents were prepared with disodium EDTA at a final concentration of 4 mmol/L. A serum calibrator and cholesterol-triglyceride and HDL-cholesterol controls provided by the Centers for Disease Control were employed essentially as described in the protocol for the Lipid Research Clinics program (10). The method of Gidez et al (11) was used for isolation of HDL. HDL_2 was then precipitated from samples of the HDL supernatant fractions by addition of dextran sulfate (MW 15 000) to a final concentration of 1.3% at 23 °C, and HDL_3 cholesterol in supernatant fractions was measured. HDL_2 cholesterol was calculated as the difference between HDL and HDL_3 cholesterol. LDL cholesterol was determined by the Lipid Research Clinics method (10). Recoveries of cholesterol in the ultracentrifugal fractions were > 95% for each sample.

Statistical analysis

The data were analyzed by paired t tests with the programs of the SAS Institute (Cary, NC). An α value of 0.05 was considered statistically significant (12). Rank correlation was used to evaluate the relative relation of blood lipids among subjects for the diets.

Results

Dietary intake

Nutrient intake data are shown in **Table 1.** There was no difference in nutrient content of the two experimental diet periods (no diet-order effect). This reflects that the body mass index of the two diet-order groups was initially balanced and weight was maintained as constant as possible throughout the experimental feeding periods.

Although the high-fat diet was formulated to reflect free-living intake based on data from similar volunteers, fat and cholesterol intake were found from analysis of diet records to be lower in self-selected diets. Prestudy self-selected intake provided 35% of energy from fat vs 41% for the high-fat diet. However, the relative amounts of saturated, monounsaturated, and polyunsaturated fatty acids were similar for the prestudy and high-fat diets. Energy from protein on the prestudy self-selected diet was approximately the same as on the high-fat diet whereas energy from carbohydrate was 4% higher and that from fat was 6% lower. Cholesterol intake on the high-fat diet was 9–11 mg/MJ (37–46 mg/1000 kcal) higher than on the self-selected diets. Dietary fiber in the high-fat diet approximated that in the self-selected diets.

TABLE 1
Mean daily intake of nutrients of subjects on self-selected and experimental diets*

	Prestudy self-selected†	High fat‡	Low fat‡	Poststudy self-selected†
Energy (%)				
Protein	14.3 ± 0.3	14.8 ± 0.0	17.1 ± 0.0	14.1 ± 0.4
Carbohydrate	50.1 ± 0.9	45.8 ± 0.0	67.3 ± 0.0	47.7 ± 1.0
Alcohol	5.1 ± 0.8	—§	—§	0.33 ± 0.1
Fat				
Total	34.7 ± 0.8	40.7 ± 0.0	18.9 ± 0.0	37.3 ± 0.9
Saturated fatty acids	12.1 ± 0.3	14.7 ± 0.0	4.4 ± 0.0	13.3 ± 0.4
Linoleic acid	6.1 ± 0.3	8.0 ± 0.0	5.2 ± 0.0	6.3 ± 0.3
Oleic acid	12.0 ± 0.3	14.1 ± 0.0	6.5 ± 0.0	13.0 ± 0.3
Cholesterol				
(mg/MJ)	36.4 ± 1.9	45.1 ± 0.0	18.1 ± 0.0	34.1 ± 2.1
(mg/1000 kcal)	152 ± 8	189 ± 0	76 ± 0	143 ± 9
Total dietary fiber				
(g/MJ)	2.0 ± 0.3	2.0 ± 0.0	4.6 ± 0.0	1.8 ± 0.1
(g/1000 kcal)	8.2 ± 1.2	8.4 ± 0.0	19.3 ± 0.0	7.6 ± 0.4

* $\bar{x}$ ± SE.
† Self-selected diets were evaluated for 7 d immediately before and 10 wk after the experimental diet periods.
‡ Experimental diets were fed in a switchover design. Diet-order groups were combined because there was no effect due to period (ie, no carryover effect).
§ Consumption of alcoholic beverages was not permitted during the experimental diet periods.

The daily consumption of fiber-containing foods was estimated from the number of servings of fruits and vegetables, legumes, and cereals and grains. One serving was considered to be a half cup of vegetables, fruits, legumes, or cereal grains; one piece of fruit; or the equivalent of one slice of nonwhite bread. The average numbers of daily servings of fruits and vegetables, legumes, and cereals and grains, respectively, for the high-fat diet were 4.7, 0.6, and 1.4 (total 6.7) and for the low-fat diet were 7.9, 3.0, and 5.3 (total 16.2).

Subjects kept food records for the poststudy self-selected diet during the tenth week after completion of the experimental feeding periods (Table 1). No significant differences, as indicated by a paired t test, were found between prestudy and poststudy intakes except for alcohol.

Blood lipids and lipoproteins

During the experimental feeding periods, measurement of lipids at 6 vs 10 wk showed no differences except for total cholesterol on the high-fat diet, where total cholesterol increased by 0.26 mmol/L from week 6 to week 10 (P = 0.002) (**Table 2**). Because of the general agreement of 6- and 10-wk lipid data, the values at 6 wk are not displayed in Table 2.

TABLE 2
Plasma lipid values of subjects consuming self-selected and experimental diets*

	Diets				Comparisons between diets: change and probability†		
	Prestudy self-selected	High fat	Low fat	Poststudy self-selected	Prestudy vs high fat	Prestudy vs low fat	High fat vs low fat
Triglycerides (mmol/L)	1.24 ± 0.09	1.14 ± 0.08	1.32 ± 0.09	1.29 ± 0.12	−0.10	+0.08	+0.18‡
Total cholesterol (mmol/L)	4.73 ± 0.12	5.17 ± 0.10	4.27 ± 0.10	4.84 ± 0.11	+0.44§	−0.47§	−0.91§
LDL cholesterol (mmol/L)	3.10 ± 0.11	3.39 ± 0.10	2.71 ± 0.10	3.10 ± 0.10	+0.28‖	−0.39§	−0.67§
HDL cholesterol (mmol/L)	1.22 ± 0.04	1.39 ± 0.05	1.11 ± 0.04	1.24 ± 0.04	+0.18§	−0.10§	−0.28§
HDL_2 cholesterol (mmol/L)	0.44 ± 0.03	0.44 ± 0.05	0.28 ± 0.03	0.39 ± 0.03	0	−0.16§	−0.16§
HDL_3 cholesterol (mmol/L)	0.78 ± 0.02	0.96 ± 0.02	0.80 ± 0.02	0.88 ± 0.03	+0.18§	+0.03	−0.16§
Total:HDL	4.1 ± 0.2	4.0 ± 0.2	4.1 ± 0.2	4.1 ± 0.2	−0.1	0.0	+0.1
LDL:HDL	2.7 ± 0.1	2.6 ± 0.1	2.6 ± 0.2	2.6 ± 0.1	−0.1	−0.1	0.0

* $\bar{x}$ ± SE. n = 42 for all values. Prestudy and poststudy values differed only for HDL_3 (P = 0.012).
† Probability, determined from a paired t test, of observing a difference this great from chance alone. $P > 0.05$ is nonsignificant.
‡ P = 0.008.
§ $P < 0.001$.
‖ P = 0.004.

Values for plasma total cholesterol, LDL cholesterol, and HDL cholesterol were lower when subjects ate the low-fat rather than the high-fat diet; triglycerides were slightly higher. Cholesterol contents of both HDL_2 and HDL_3 were significantly reduced by the low-fat diet but ratios of total cholesterol to HDL cholesterol and LDL to HDL cholesterol did not differ by diet.

Changes between the low-fat and self-selected diets were similar to those between the low-fat and high-fat diets but were smaller. Concentrations of total, LDL, HDL, and HDL_2 cholesterol decreased for the low-fat diet compared with the prestudy self-selected diet. However, triglycerides and HDL_3 cholesterol did not change significantly.

The magnitude of plasma cholesterol reduction associated with the low-fat diet varied widely among individuals. Responses ranged from a 4% increase in plasma cholesterol to a 38% reduction compared with the high-fat diet. The maximum reduction observed for LDL cholesterol was 55%; most subjects (n = 25) had reductions of 11–30%. Lesser but still impressive reductions in cholesterol were observed when the self-selected diets were compared with the high-fat diet. Five individuals exhibited either no change or an increase (1–11%) in plasma cholesterol whereas decreases as high as 31% for total cholesterol and 33% for LDL cholesterol were observed.

Subjects followed roughly similar rankings based on their levels of total and lipoprotein cholesterol after consuming each diet. For total cholesterol, the rank correlations range from 0.57 for the self-selected diet with the high-fat diet to 0.63 for the high-fat with the low-fat diet. For HDL cholesterol the range is 0.83 for the self-selected diet with the low-fat diet to 0.89 for the high-fat with the low-fat diet. For LDL cholesterol the range is 0.60 for the self-selected diet with the low-fat diet to 0.71 for the self-selected with the high-fat diet.

Differential responses of men with total or LDL-cholesterol concentrations either above or within the desirable range, based on NCEP classification, are shown in **Table 3.** Subjects were classified as either above or within the desirable range based on their plasma concentrations after eating the high-fat diet for 10 wk. Twenty-two subjects had plasma total cholesterol concentrations above the desirable range (≥ 5.17 mmol/L), whereas 20 were above the desirable range for LDL cholesterol (≥ 3.36 mmol/L). Of the subjects with total cholesterol or LDL-cholesterol values above the desirable concentration while eating the high-fat diet, most were classified as borderline high. However, three had total cholesterol values of 6.21–7.27 mmol/L and five had LDL-cholesterol values of 4.14–5.30 mmol/L and therefore had high-risk concentrations while eating the high-fat diet. The ages ($\bar{x}$ ± SE) of subjects above and within the desirable range were similar: for total cholesterol, 35 ± 2 and 33 ± 2 y, respectively; for LDL cholesterol, 36 ± 2 and 33 ± 2 y, respectively.

In a comparison of subjects above and within the desirable range, no significant differences were found for the percent reductions of total, LDL-, and HDL-cholesterol concentrations. However, when expressed as absolute reductions, LDL-cholesterol reduction was greater for subjects above rather than within the desirable range for LDL cholesterol (0.85 ± 0.158 vs 0.52 ± 0.059 mmol/L, P = 0.054). No significant differences in absolute changes were seen in other lipoprotein fractions by cholesterol classification.

The last column of Table 3 shows the percent reduction in plasma cholesterol for all subjects combined, without regard to guidelines. The average reductions in total cholesterol, LDL cholesterol, and HDL cholesterol were very similar. However, the average reduction in HDL_2 cholesterol (the larger, less-dense subfraction) was greater than that of HDL_3 (14%).

TABLE 3
Differential response to diet of men with total- or LDL-cholesterol concentrations either above or within the desirable range designated by the National Cholesterol Education Program (3)*

	Total cholesterol		LDL cholesterol		
	<5.17 mmol/L	≥5.17 mmol/L	<3.36 mmol/L	≥3.36 mmol/L	All subjects
			%†		
Total	16 ± 2	18 ± 2	16 ± 2	19 ± 2	17 ± 1
LDL	19 ± 2	20 ± 3	18 ± 2	21 ± 3	20 ± 2
HDL	17 ± 2	22 ± 2	20 ± 2	20 ± 2	20 ± 2
HDL_2	23 ± 12	21 ± 9	23 ± 11	21 ± 10	22 ± 7
HDL_3	11 ± 3	16 ± 3	12 ± 23	15 ± 3	14 ± 2

* $\bar{x}$ ± SE.
† Percent reduction = [(high fat − low fat)/high fat] × 100.

Although the averages of percent reduction in LDL and HDL cholesterol were both 20%, implying a parallel decrease in these lipoproteins, individual subjects exhibited substantial heterogeneity in their own LDL and HDL reductions. The weak correlation observed for percent reduction of LDL cholesterol with percent reduction in HDL cholesterol (r = 0.24, P = 0.13) indicates that the low-fat diet affected LDL and HDL cholesterol of individuals independently.

Discussion

Multiple dietary changes are involved in implementing a low-fat diet. In addition to less total fat, such diets typically contain proportionately less saturated fatty acid, less cholesterol, and more carbohydrate, including fiber-rich foods such as beans, cereals, fruits, and vegetables. To accentuate differences in response to diet, in this study the low-fat diet was lower in fat and considerably higher in fiber than diets generally advocated for cholesterol reduction. For example, the NCEP Step One Diet (13) could provide more total fat (< 30% of calories), saturated fatty acids (< 10% of calories), and cholesterol (< 300 mg/d), and a quantitative goal for consumption of dietary fiber is not stated.

Although reduced intake of saturated fatty acids is generally recognized as the major dietary factor responsible for lowering plasma cholesterol concentrations (14, 15), there is considerable evidence of the beneficial effects of increased consumption of fiber on blood lipids (16, 17). The degree of cholesterol reduction achieved with the low-fat diet was evaluated in relation to cholesterol concentrations of subjects eating either their habitual (self-selected) diets or a high-fat diet. Both of these diets were high in total fat, saturated fatty acids, and cholesterol and lower in fiber than is currently thought to be desirable but were similar to current American intakes.

Significant reductions in cholesterol concentrations were found when subjects ate the low-fat diet rather than the high-fat diet or their self-selected diets. Both plasma cholesterol and LDL cholesterol fell sharply during the first 6 wk of the low-fat diet with no further reduction from week 6 to week 10. After 10 wk of eating the high-fat diet, mean cholesterol concentrations shifted from the desirable range to the lower limits of the borderline-high category for both plasma cholesterol and LDL cholesterol. The mean concentration of plasma cholesterol for subjects eating the low-fat diet was below 4.40 mmol/L, which has been equated with extremely low risk of CHD (18, 19). Such low-risk concentrations are common for North American males only during early adulthood (13, 20). Results of the present study indicate that with low-fat, high-fiber diets such as those used in this study, many, if not most, American males could reduce their plasma cholesterol concentrations substantially.

Our subjects were not inclined to adopt a low-fat eating pattern after the study. Although subjects ate the low-fat diet with little complaint, they appear to prefer a higher fat content as judged by their return to the higher-fat typical American diet during the poststudy period.

We compared the cholesterol reductions observed in this study to those predicted by two scoring systems, that of Keys et al (21) and a more recent formula, the Cholesterol/Saturated-Fat Index (CSI) proposed by Connor et al (14). Unlike the scoring system of Keys et al, the formula for the CSI does not include polyunsaturated fatty acids, only saturated fatty acids and cholesterol. This is consistent with recent evidence that polyunsaturated fatty acids reduce plasma cholesterol mainly by replacing saturates rather than by acting independently (22). When comparing the low-fat with the high-fat diet, the observed reduction in plasma cholesterol was 90% of that predicted by the formula of Keys et al and 219% of that predicted by the CSI. The reduction in plasma cholesterol associated with feeding the low-fat diet rather than the self-selected diets was in the same direction, although less impressive: 67% for the formula of Keys et al and 150% for the CSI.

The degree of change in plasma cholesterol associated with the low-fat diet varied widely among subjects but clearly showed a sharp overall decline. The percent of subjects experiencing a reduction in plasma cholesterol of > 0.52 mmol/L was high, 59% for the change from self-selected diets to the low-fat diet and 79% for the change from the high-fat diet.

Subjects with total- and LDL-cholesterol concentrations above the desirable range while eating the high-fat diet did not have a greater degree of reduction in these indices as a result of eating the low-fat diet than did their counterparts with desirable lipid concentrations, ie, the percent reduction was equivalent in the two groups. Even subjects who had lipid concentrations within the desirable range while eating the high-fat diet experienced significant reductions in plasma and lipoprotein cholesterol concentrations when they consumed the low-fat diet. Their mean plasma cholesterol concentrations changed from 4.65 ± 0.085 to 3.90 ± 0.129 mmol/L and LDL cholesterol fell from 2.90 ± 0.101 to 2.38 ± 0.122 mmol/L while eating the low-fat diet ($P < 0.001$ for both).

Reduction of plasma cholesterol to levels approaching 3.88 mmol/L may have a great impact on arterial walls. Based largely on animal studies summarized by Malinow (23), Small (24) concluded that lipid is mobilized from atherosclerotic lesions at plasma cholesterol concentrations of 3.88 mmol/L. Only one of our subjects had a plasma cholesterol concentration as low as 3.88 mmol/L after eating the high-fat diet for 10 wk, a sharp contrast to the 11 subjects (26%) who attained this concentration while eating the low-fat diet.

We have interpreted the results of this study based mainly on the reduction of LDL cholesterol, because LDL is the only lipoprotein where modulation has been shown, beyond a doubt, to alter the pathogenesis of human CHD. However, the concomitant reduction of HDL in this study should not be minimized. There is considerable evidence from population studies (25–28) and from a drug trial (29) that HDL-cholesterol concentrations are inversely related to CHD risk. However, the mechanism for this protection has not been well-delineated.

Dietary approaches other than the low-fat, high-fiber model used in this study may produce equal, and perhaps superior, results. For example, substitution of monounsaturated for saturated fatty acids (30) or for specific saturated fatty acids (31) may significantly improve plasma lipid profiles without lowering HDL cholesterol. We chose to assess the efficacy of a low-fat diet because reductions in total fat and saturated fatty acids are recommended for the US population (3) and because populations that routinely consume diets that are high in carbohydrate and low in total fat and saturated fatty acids tend to have low CHD rates (19).

In an ecological analysis of plasma cholesterol concentrations in populations where the normal diet has different amounts of fat and carbohydrates, Knuiman et al (32) reported that the average plasma total-cholesterol and HDL-cholesterol concentrations varied in tandem, both values being low in societies eating low-fat, high-carbohydrate diets and both values being high in more-affluent societies where high-fat, low-carbohydrate diets are more common. Our mean values for total cholesterol and HDL cholesterol are consistent with this observation. However, we found little evidence to support this idea at the level of the individual consuming controlled diets. That is, an individual consuming the low-fat diet is likely to have a proportionately greater reduction in LDL cholesterol relative to HDL cholesterol, or vice versa, even though mean values for LDL and HDL cholesterol decrease in parallel.

In this study, the mean value for HDL_2 was reduced proportionately more than HDL_3 in response to the low-fat diet. Such relative reductions in HDL_2 have also been noted in subjects who consumed low-fat rather than high-fat diets (33), in subjects who ate diets with a high ratio of polyunsaturated to saturated fatty acids (34), and in subjects with reduced intakes of dietary cholesterol (35). Thus, controlled feeding studies have shown that most of the dietary changes that are thought to be beneficial with regard to CHD will reduce HDL_2 cholesterol.

In summary, this study provides evidence that diet can be a powerful modulator of plasma and lipoprotein cholesterol concentrations. Men committing to such a diet could reasonably expect a reduction in plasma cholesterol > 0.52 mmol/L as was experienced by 59% of our subjects who changed from their usual diets and 79% who changed from the high-fat diet. With faithful adherence to a diet low in fat, saturated fatty acids, and cholesterol and high in plant fiber, marked reductions in plasma cholesterol and LDL cholesterol occur within 6 wk. Positive effects from low-fat diets were seen in the majority of men, including those with desirable as well as those with higher concentrations of plasma and LDL cholesterol.

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